Effect of Sulphates (Na_2So_4) On Concrete with Sugarcane Bagasse Ash as a Pozzolana

P V Rambabu, K.Dendhendra Gupta, G V Ramarao

Abstract— **This paper presents the results of an experimental work that was carried out to determine the effect of sugarcane bagasse ash (SCBA) on the durability of concrete to Sulphate attack when Sugarcane Bagasse ash is utilized as cement replacement material. Sugarcane bagasse ash (SCBA) is a fibrous waste product obtained from sugar mills as byproduct, which is obtained by burning of Sugarcane Bagasse at 700 to 800 degree Centigrade in sugar refining industry. The Bagasse Ash, then ground until the particles passing the 90 micron. Sugarcane Bagasse ash mainly contains aluminium ion, silica, iron & calcium oxides. The objective of this work is to study the influence of partial replacement of cement with sugarcane bagasse ash in concrete subjected to different curing environments. A study on salt resistance of concrete using Na_2So_4 Solution is observed. The variable factors considered in this study were concrete of grade M35 for a curing period of 28 days, 60 days and 90 days of the concrete specimens in 1%, 3%, 5% Na_2So_4 solution. Bagasse ash has been partially replaced in the ratio of 0%, 5%, 6%, 7%, 8%, 9%, and 10% by weight. The effect of Sodium Sulphate is determines by the loss of strength with respect to the conventional concrete which has been determined.**

Index Terms— **compressive strength, durability, Sodium Sulphate, Sugarcane Bagasse ash.**

I. INTRODUCTION

Now-a-days the most suitable and widely used construction material is concrete. This building material, until these days, went through lots of developments. The most important part of concrete is cement. Cement manufacturing is a highly energy intensive process, which involves intensive fuel consumption for clinker making and resulting in emission of Green house gases like carbon dioxide (CO_2) in large amount ,which is very harmful for the environment[1]. In order to minimize this problem we use the concept of supplementary cementations material. The larger quantity of agriculture waste like rice husk ash, sugarcane bagasse ash, palm oil fuel ash, olive oil ash etc and Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as supplementary cement replacement materials which are being a waste, dumping of these industrial and Agricultural wastes in open land poses a serious threat to the society by polluting the air and water bodies. This also adds, the no availability of land for public use[2]-[3].

One of the agro waste sugar cane bagasse ash (SCBA), which is a fibrous waste product obtained from sugar mills as byproduct. Juice is extracted from sugar cane then ash produced by burning bagasse in uncontrolled condition and at very high temperature. The ash therefore becomes an industrial waste and poses disposal problems [4]. Bagasse ash mainly contains aluminum ion, silica, iron & calcium oxides.. So few studies have been reported that sugarcane bagasse ash as good pozzolanic material used as a partial replacement of cement.[5]-[6].

The present study was carried out on SCBA obtained by controlled combustion of sugarcane Bagasse, which was procured from the industry has agricultural waste. Bagasse is a major by-product of the sugar industry, which is utilized in the same industry as an energy source for sugar production. Sugar cane bagasse ash is most common type of by-product of agricultural waste. Approximately 1500 Million tons of sugarcane is annually produced over all the world which leave about 40-45 % bagasse after juice crushing for sugar industry giving an average annual production of 675 Million tons of bagasse as a waste material. This can be used as a replacing material in concrete gives Compressive strength result, shows that up to 10% replacement of sugar cane bagasse ash in concrete gives comparable result with normal concrete without any admixture[7]-[8]-[11].

[9]-[10] Describes the compressive strengths of concrete (with 0%, 5%,10%,15% and 20%, weight replacement of cement with SCBA) cured in different concentrations of(1%, 2%, 3%, 4%, 5%) Magnesium sulphate solution for 7, 28, 60 ,90 and 180, indicate that at 5% replacement there is increase in strength and it extended up to 10% replacement and then decrease in strength is noticed at 15% and 20% replacements. And Inclusion of SCBA in concrete regardless the replacement level significantly improved the sulphate resistance of concrete by reducing the weight loss and strength loss due to sulphate attack. The minimum weight loss and strength loss obtained were 1.2% and 2.2% respectively at 15%SCBA. In this paper, the objective is to study the influence of partial replacement of Portland cement with sugarcane bagasse ash in concrete subjected to Na_2So_4 curing environment The variable factors considered in this study were concrete grade of M35 & curing periods of 28, 60, 90 days of the concrete specimens are curing in 1%, 3%, and 5% Na_2So_4 solution. Bagasse ash has been partially replaced in the ratio of 5%, 6%, 7%, 8%, 9%, 10% by weight. After curing of 28, 60, 90 days of the concrete specimens in 1%, 3%, and 5% Na_2So_4 solution, we obtained compressive strength at that age and also durability aspect of sugarcane bagasse ash concrete for sulphate attack was tested.

II. EXPERIMENTAL MATERIALS

2.1 Sugarcane Bagasse Ash:

Sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicelluloses of ligin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The

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residual after combustion presents a chemical composition dominates by silicon dioxide (sio_2). In spite of being a material of hard degradation and that presents few nutrients, the ash is used on the farms as a fertilizer in the sugarcane harvests. In this project bagasse ash was collected from the industry.

Fig.1 Sugarcane bagasse ash

2.1.1 Physical properties of SCBA:

S. No	Property	Test Result
1.	Colour	Reddish Grey
2.	Bulk Density(Kg/m^3)	994
3.	Specific Gravity	2.88
4.	Moisture(%)	3.14
5.	Mean particle size(μm)	0.1-0.2
6.	Particle shape	Spherical
7.	Specific Surface area(m^2/Kg)	514

2.1.2Chemical properties of SCBA:

S. No	Component	Symbol	Percentage weight
1.	Silica	SiO_2	64.59
2.	Alumina	Al_2O_3	4.38
3.	Ferric Oxide	Fe_2O_3	6.98
4.	Calcium Oxide	CaO	11.8
5.	Magnesium Oxide	MgO	2.51
6.	Sulphur Trioxide	SO_3	1.48
7.	Potassium Oxide	K_2O	3.53
8.	Loss on Ignition	LOI	4.73

2.2 CEMENT

The cement used was ordinary Portland cement (OPC) of 53 grade having a Standard Consistency of 32%. Specific care has been taken to store it in airtight containers to prevent it from being affected by the atmospheric and monsoon moisture and humidity.

2.3 FINE AGGREGATE

: Locally available free of debris and nearly riverbed sand is used as fine aggregate. The river sand, passing through 4.75 mm sieve and retained on 600 μm sieve, conforming to Zone II as per IS 383-1970 was used as fine aggregate in the present study. The properties of sand such as fineness modulus and specific gravity were determined as per IS: 2386-1963.

2.4 COARSE AGGREGATE

The crushed aggregates used were 20mm nominal maximum size and are tested as per Indian standards and results are within the permissible limit. It is free from impurities such as dust, clay particles and organic matter etc.

2.5 WATER

The water used in the mixing of concrete was portable water and it is free from suspended solids and organic materials. The p^H value should be in a range 6-8.5 according to P^H scale. Conforming to the requirements of water for concreting and curing are as per IS: 456-2009.

III. EXPERIMENTAL PROCEDURE

3.1 Mixing

The cementations materials are thoroughly blended and then the aggregate is added and mixed followed by gradual addition of water and mixing. Wet mixing is done until a mixture of uniform color and consistency are achieved which is then ready for casting. Before casting the specimens, workability of the mixes was found by compaction factor test.

3.2 Casting of specimens:

The cast iron moulds are cleaned of dust particles and applied with mineral oil on all sides before concrete is poured in to the moulds. The well mixed concrete is filled in to the moulds by vibration. Excess concrete was removed with trowel and top surface is finished to level and smooth as per IS

516-1969.

Fig.2 Casted Specimens

3.3 Curing of the specimens:

The specimens are left in the moulds undisturbed at room temperature for about 24 hours after casting. The specimens are then removed from the moulds and immediately transferred to the curing pond containing clean and fresh water and cured for required period as per IS: 516-1969**.**

3.4 Durability:

In present project, the durability tests are conducted by partial replacement of sugarcane bagasse ash against Na_2So_4 salt. The response of Na_2So_4 attack on sugarcane bagasse ash concrete for various percentages was studied by observations like loss in strength. For conducting these tests, concrete cubes with different percentages were casted. These cubes were immersed in 1%, 3% and 5% solution of Na_2So_4 for different periods of 28, 60, and 90 days, and deterioration was studied by means of loss of strength.

3.5 Testing of specimens on compression machine:
The compression testing machine used for testing the cube specimens is of standard make. The capacity of the testing machine is 2000 KN. The machine has a facility to control the rate of loading value.
After the required period of curing, the cube specimens are removed from the curing tank and cleaned to wipe off the surface water. It is placed on the machine such that the load is applied centrally. The smooth surfaces of the cube are placed on the bearing surfaces. The top plate is bought in contact with the specimen by rotating the handle. The oil pressure valve is closed and the machine is switched on. A uniform rate of loading 140kg/sq.cm/min is maintained.

Fig.3 Testing of Specimen

IV. EXPERIMENTAL RESULTS

Table 1: Compressive strength results for cubes cured in water

% of SCBA	Compressive strength N/mm^2 at 28 days,	Compressive strength N/mm^2 at 60 days,	Compressive strength N/mm^2 at 90 days,
0%	46.19	56.82	59.99
5%	47.08	57.54	60.18
6%	48.99	59.59	62.76
7%	47.16	58.99	61.10
8%	45.72	57.10	59.86
9%	44.62	55.76	58.17
10%	47.99	58.06	60.96

Table 2: Compressive strength results for cubes cured in 1% Na_2SO_4 solution

% of SCBA	Compressive strength N/mm^2 at 28 days	Compressive Strength N/mm^2 at 60 days	Compressive Strength N/mm^2 at 90 days
0%	44.60	54.97	58.40
5%	45.25	55.90	59.24
6%	46.79	56.81	60.76
7%	44.99	54.76	59.16
8%	43.56	53.06	57.76
9%	42.99	52.18	56.18
10	46.55	56.29	59.99

Table 3: Compressive strength results for cubes cured in 3% Na_2SO_4 solution

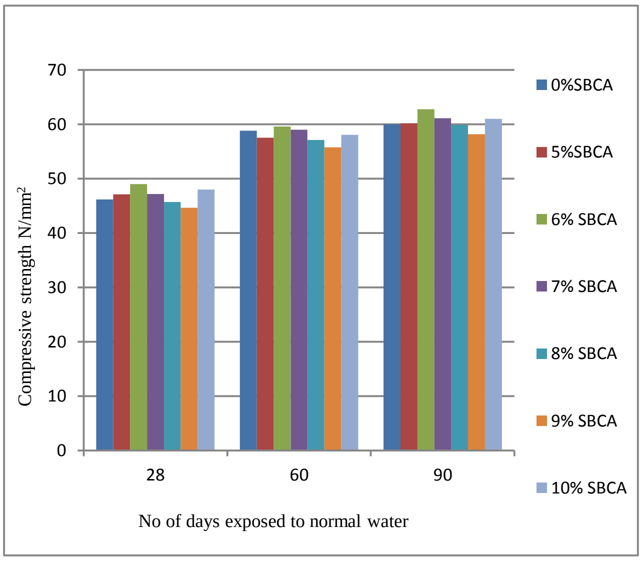
% of SCBA	Compressive strength N/mm^2 at 28 days	Compressive Strength N/mm^2 at 60 days	Compressive Strength N/mm^2 at 90 days
0%	43.99	53.76	57.09
5%	44.56	54.99	57.61
6%	46.17	55.55	58.98
7%	45.76	53.16	56.78
8%	43.12	52.76	55.12
9%	42.76	51.02	53.86
10%	44.96	55.04	57.99

Table 4: Compressive strength results for cubes cured in 5% Na_2SO_4 solution

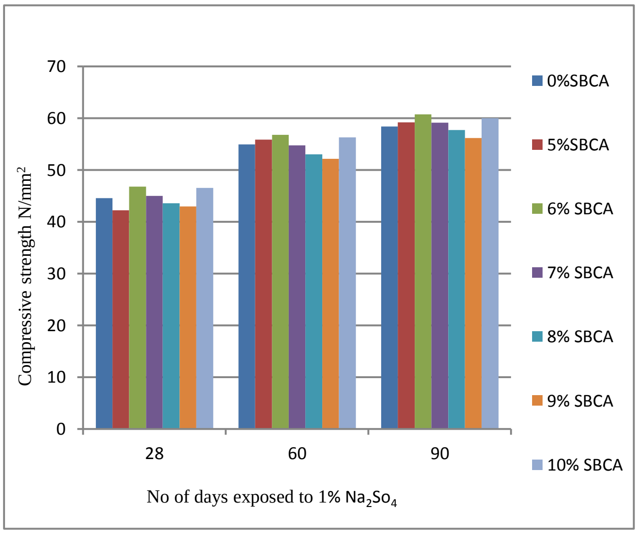
% of SCBA	Compressive strength N/mm^2 at 28 days	Compressive Strength N/mm^2 at 60 days	Compressive Strength N/mm^2 at 90 days
0%	42.82	52.92	55.00
5%	43.76	54.01	56.18
6%	45.76	55.68	57.76
7%	44.89	53.89	55.76
8%	42.76	52.76	54.86
9%	41.86	51.68	52.10
10%	44.12	54.99	56.79

V. DISCUSSIONS

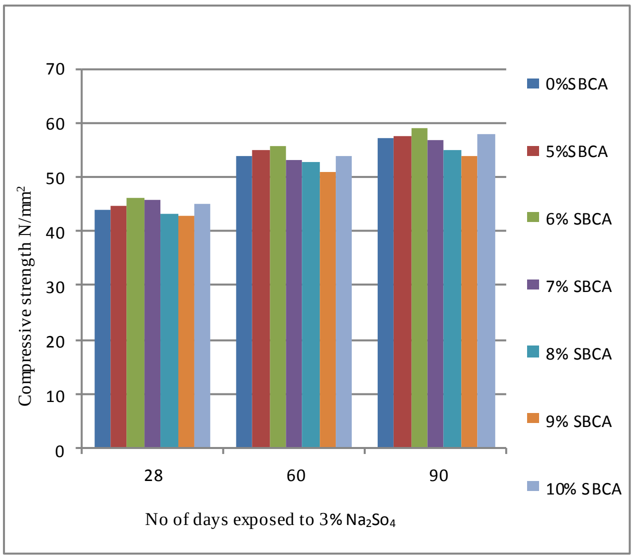
The SCBA was replaced by weight of cement in 5%, 6%, 7%, 8%, 9%, & 10% respectively in concrete. The concrete cubes which are replaced with SCBA are cured in normal water in order to study the durability of concrete. It exposed to Na_2So_4 solution in 1%, 3% & 5% in 28days, 60days & 90days respectively. The compressive strength of concrete specimens results are presented graphically from graph 1 to 4. From all graphs it is seen that the compressive strength increases with the age of days. Graph 1 shows the cubes cured in normal water. From graph it can be seen that the compressive strength of concrete cubes increases with increase in different periods of curing. For different period of curing, an increase in compressive strength is observed up to 6% replacement and a decrease in strength is observed at 7%, 8% and 9% replacement and a slight increase is observed at 10% replacement. Graphs 2, 3, 4 shows the results for SCBA concrete cubes exposed to 1%, 3% and 5% Na_2So_4 solution. From the graphs it can be seen that the compressive strength of SCBA replaced concrete cubes increases with increase in the period of exposure for all percentages of replacement in Na_2So_4 Solution. For different period of curing, an increase in compressive strength is observed up to 6% replacement and a decrease in strength is observed at 7%, 8% and 9% replacement and a slight increase is observed at 10% replacement. From the above graphs it is clear that, 6% replacement of SCBA is the optimum level of replacement for higher strength of concrete.
GRAPH.1: Compressive strength results of SBCA Concrete cured in normal Water



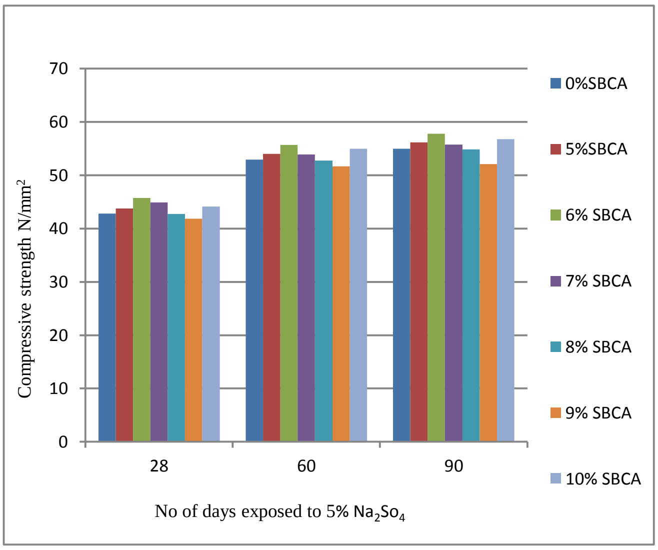
GRAPH.1: Compressive strength results of SBCA Concrete cured in 1% by volume Na_2So_4 solution



GRAPH.3: Compressive strength results of SBCA Concrete cured in 3% by volume of Na_2So_4 solution



GRAPH.4: Compressive strength results of SBCA Concrete cured in 5% by volume of 1% Na_2So_4 solution



VI. CONCLUSION

The following conclusions have been made based on the work carried out:

I. The compressive strength tests are conducted and observed that specimens have reached the target mean strength.

II. The results show that the SCBA concrete had significantly higher compressive strength compare to that of the concrete without SCBA.

III. The compressive strengths of sugarcane bagasse ash replaced concrete cubes increases with increase in age of curing for all percentages of replacements in normal water.

IV. The compressive strengths of sugarcane bagasse ash replaced concrete cubes also increases with increase in age of curing for all percentages of replacements in different percentages of $MgSo_4$ Solution.

V. The partial replacement of SCBA in cement not only enhances the strength to the concrete but also prevent it from the attack of sulphates.

VI. It is found that the cement can be replaced with SCBA for 6%, which is the optimum value of replacement.

VII. It was clearly shown that SCBA is a pozzolanic material, such that it can be used as partial cement replacement material and can contribute to the environmental sustainability.

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